# Radar Detection of Marine Mammals

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## LONG-TERM GOALS

The long term goal is to develop a radar solution for the detection of marine mammals using ship-borne radar and demonstrate its performance. In particular, a solution using commercial surface search radars is desired as it provides a readily accessible technique for commercial shipping concerned about ship strike of marine mammals and/or detection for compliance with operating permits.

## OBJECTIVES

There are two technical objectives for this work. The first is to develop a near-real-time signal processor/radar combination that is suitable for the detection of marine mammals. The second objective is to assess the performance of such a combination in specific ocean conditions / species combinations in order to establish the utility of such a system.

## APPROACH

The general approach is to iterate between experimental results and processing improvements. As such, the current work represents one cycle of development. There are three elements to the approach as follows:

The first task is to collect a data set from a fixed location. The dataset should have significant diversity in (a) look directions, (b) range from the radar and (c) sea conditions. The dataset should have sufficient animals to make a statement about both probability of detection (PD) as well as false alarm rate (FAR).

The second task is to make an assessment of the performance of the radar plus signal processing algorithm for the detection of marine mammals

The third is to convert the algorithm into a low-latency processor suitable for a ship borne application where a mitigation action may need to be undertaken in response to a detection.

The resulting processor will then be tested in a ship borne test. This will be followed by a number of iterations to improve both the timeliness of the processor as well as a reduction in the FAR.

# Report Documentation Page

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**The long term goal is to develop a radar solution for the detection of marine mammals using ship-borne radar and demonstrate its performance. In particular, a solution using commercial surface search radars is desired as it provides a readily accessible technique for commercial shipping concerned about ship strike of marine mammals and/or detection for compliance with operating permits.**

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## WORK COMPLETED

A major effort for this year was to prepare for an at-sea test. This was originally planned for late August but has been moved to November. We will be accompanying the NOAA Southwest Fisheries "Ecosystem Survey of Delphinus Species" cruise aboard the MacArthur II. For this test, we will be tapping into the existing ship's Furuno radar and as such this is a good example of how we hope to operate in the future (See **Figure 1**). We have obtained a new data acquisition card for the radar and have written custom software to both acquire and display radar data. We expect to perform off-line tracking analysis during the cruise.


***Figure 1. NOAA R/V MacArthur II. The red circle highlights the 8 ft Furuno radar to be used in the upcoming experiment.***

The second major effort has been to move the detection and tracking operations from the semi-manual operation of the previous year to an implemented processor. Towards that end, we have formalized the pre-processing and single frame detection actions and combined it with an associative tracker.

## RESULTS

The detection and tracking algorithm has been developed using data from the previous year's MAST08 data collection. For testing, we have been using a challenging data case from January xx. For that day, the visual observers reported A Beaufort 2-3 for the day, but the closest wave buoy had a significant wave height of 1.2 m indicating a Beaufort 4 condition. While the false alarm rate is significant, we have been able to successfully identify and track Grey whales on their southern migration.

**Figure 2** shows a raw and processed radar sweep. The plot on the left is proportional to the log of the return power and is similar to what a ship's operator would see when the display threshold is turned down. Typically an operator would raise the threshold so that only ships are seen and the sea clutter suppressed. The plot on the right shows the same single sweep after our single-frame processing. This

has increased the contrast between various features and the surrounding noise. The streaking in the sweep direction is caused by the size of the radar beam sweeping across small objects. The cluster of clutter in the near range, south corner is due to near-shore effects that were often present.

**Figure 3** shows the detection and tracking results as seen on this single sweep. The left hand plot shows the same image as in **Figure 2** but with all single-sweep detections marked with circles. Each of these has passed a number of requirements regarding intensity and shape. There are a total of 21 detections on this sweep, most of which are not marine mammals. The next step in rejecting the false detections is to apply a tracker. The basic concept is to find short tracks that have characteristics consistent with marine mammal behavior. For example, birds that are detected by the radar can often be rejected because they move too fast. Of the original 21 detections, 14 do not form tracks and are rejected. Of the remaining seven, four are found to have speeds too fast to be marine mammals. This leaves the three whale detections shown in the plot of the right of **Figure 3**. One of these three is a known whale pod as identified by the visual observer team. The other two are either additional whales not spotted by the visual team or are false alarms. It is interesting to note that all three detections fall along the general line that the visually-observed grey whales were following.

**Figure 4** shows a comparison of the track the visual observer team generated (orange) and the series of short tracks found by the radar (green). These tracks are both co-located in space as well as in time. Together they demonstrate that the radar plus processor is indeed finding Grey whales during the southern migration. However, **Figure 4** does not show the other potential tracks that were found during the same time period. At this stage of development, the processor is generating too many false alarms at least in this robust sea. Nonetheless, the processor is effectively finding marine mammals. Further development of the tracker is planned.

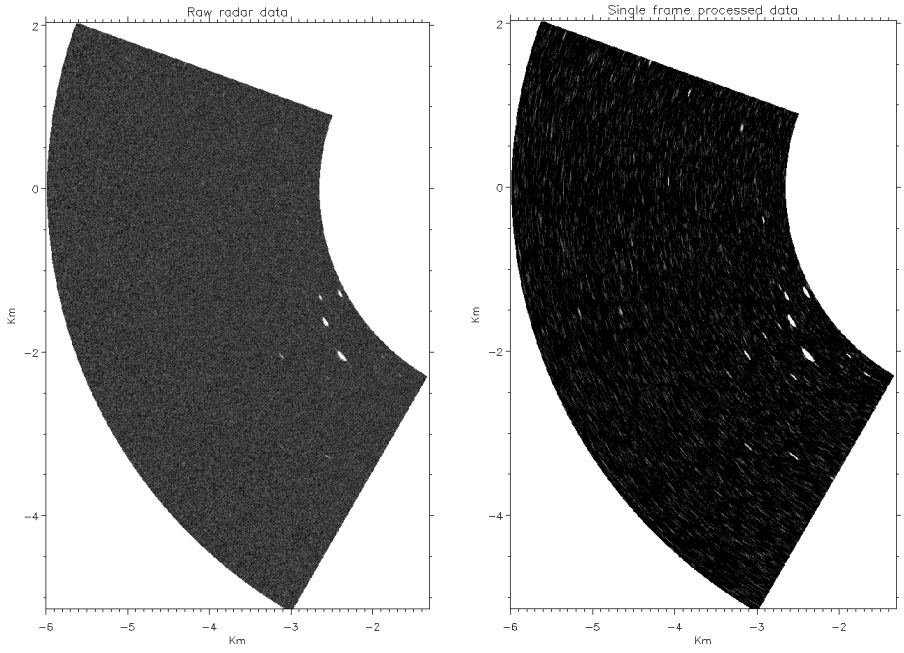


***Figure 2. The left image shows a single radar sweep as an unprocessed output. The image on the right shows same frame as processed prior to detection. Note the increased sharpness of the bright objects.***

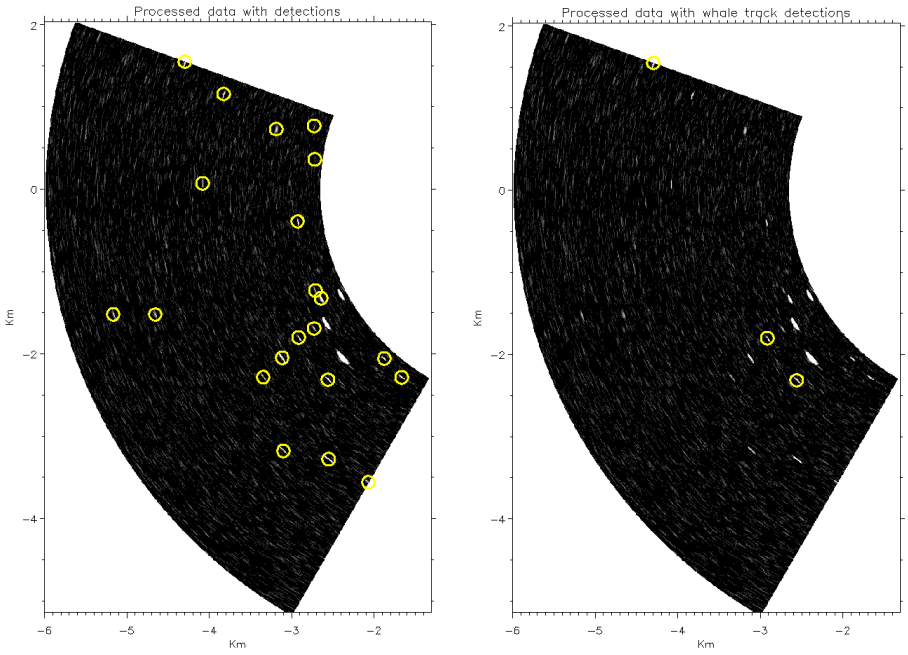


***Figure 3. The left hand image shows the 21 single frame detections. Note the clustering at the lower right hand section where near-shore effects are prevalent. The right hand image shows the three final three candidate whales after tracking is applied.***

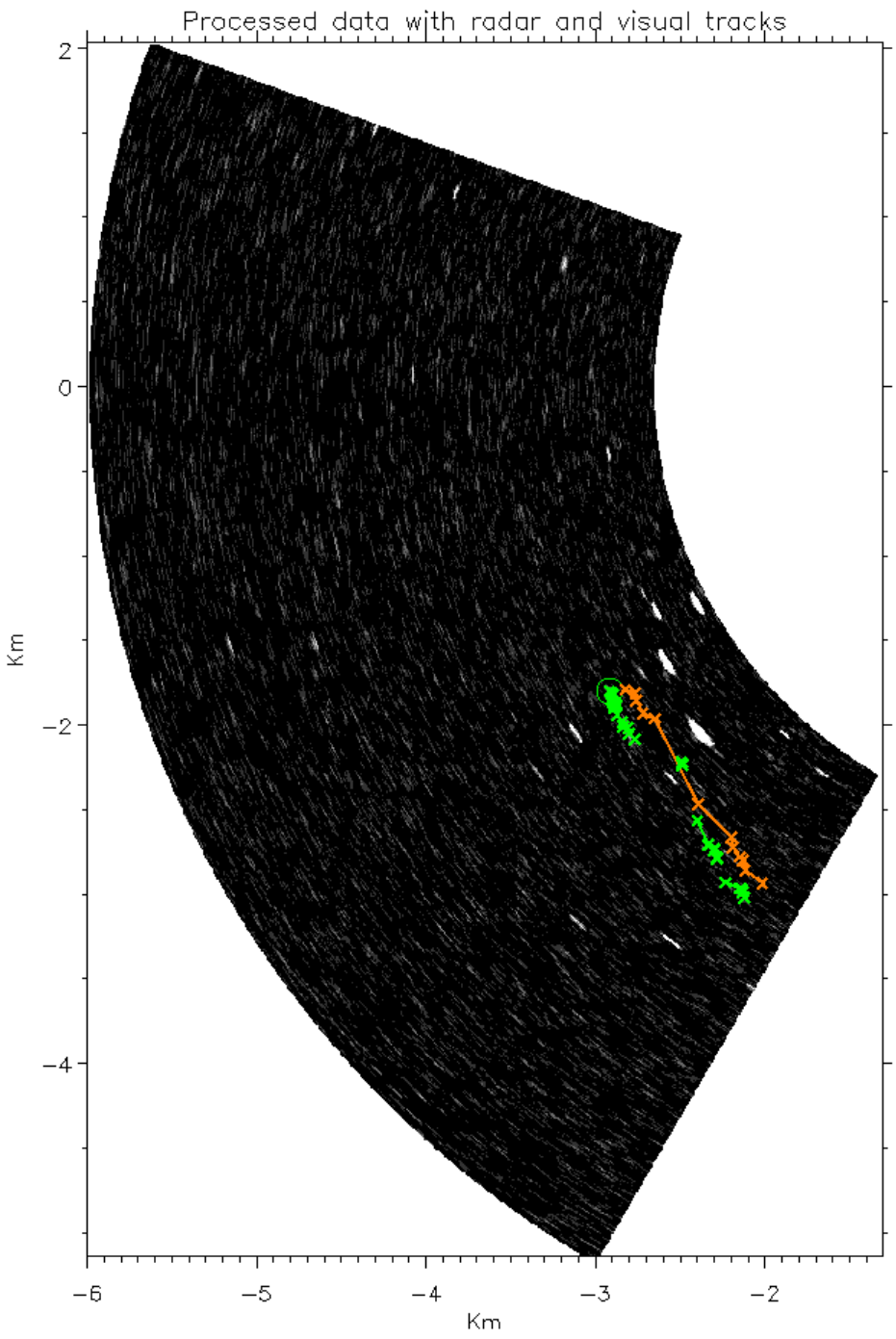


***Figure 4. The image shows the single frame processed image with the determined whale tracks as an overlay. The orange line shows the tracks as identified by visual observers. The green lines show the individual radar tracks for this pod. The green circle is the original detection.***

## IMPACT/APPLICATIONS

The project can provide a significant new capability for operations in and around marine mammals. If the commercial radar approach is succesfull, a relatively low-cost solution will be available to detect and track marine mammals. This capability can be used to extend operations into low visibility conditions (e.g. night and fog) for both ship strike avoidance applications as well as area clearance operations around active sources. Since the capability can be configured to use existing radars, there is relatively low impact on commercial ships use of the technology. Similar approaches can be developed for military-grade radars if desried.

## RELATED PROJECTS

None.